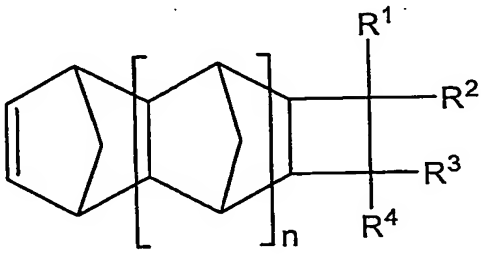
CLAIMS

What is claimed is:

1. A fluorine-containing copolymer comprising:
   (a) at least one repeat unit derived from an ethylenically unsaturated compound having at least one fluorine atom covalently attached to an ethylenically unsaturated carbon atom; and
   (b) at least one repeat unit derived from an ethylenically unsaturated cyclic compound of structure (I):



(I)

wherein n is 0, 1, or 2; and

R^1 to R^4 are independently H; $C_1 - C_{10}$ alkyl or alkoxy, optionally substituted by halogen or ether oxygens; or $C_6 - C_{20}$ aryl.

2. The copolymer of Claim 1, wherein (a) is derived from a fluoro-olefin comprising 2 to 20 carbon atoms.

3. The copolymer of Claim 2, wherein the fluoro-olefin is selected from the group consisting of tetrafluoroethylene; hexafluoropropylene; chlorotrifluoroethylene; vinylidene fluoride; vinyl fluoride; perfluoro-(2,2-dimethyl-1,3-dioxole); perfluoro-(2-methylene-4-methyl-1,3-dioxolane); $CF_2=CFO(CF_2)_tCF=CF_2$, wherein t is 1 or 2; and $R_f"OCF=CF_2$ wherein $R_f"$ is a saturated fluoroalkyl group of from 1 to 10 carbon atoms.

4. The copolymer of Claim 3, wherein the fluoro-olefin is tetrafluoroethylene.

5. The copolymer of Claim 1, further comprising a fluoroalcohol group or a protected fluoroalcohol group.

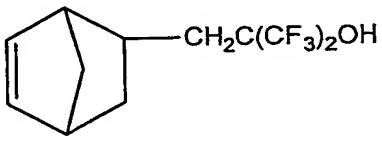
6. The copolymer of Claim 5, wherein the fluoroalcohol group or the protected fluoroalcohol group is derived from at least one ethylenically unsaturated compound containing a fluoroalcohol group having the structure:

$-C(R_f)(R_f')OH$

wherein R_f and R_f' are the same or different fluoroalkyl groups of from 1 to 10 carbon atoms, or taken together are $(CF_2)_m$ wherein m is 2 to 10.

7. The copolymer of Claim 6, wherein R_f and R_f' are perfluoroalkyl groups.

8. The copolymer of Claim 6, wherein the ethylenically unsaturated compound containing the fluoroalcohol group or the protected fluoroalcohol group is derived from a monomer selected from the group consisting of:



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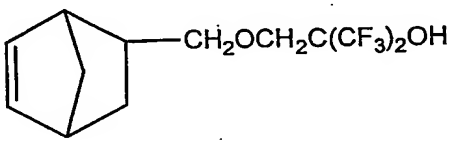

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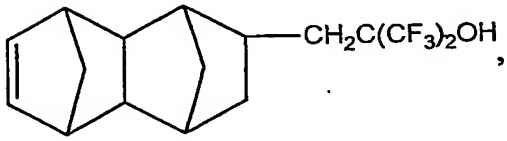

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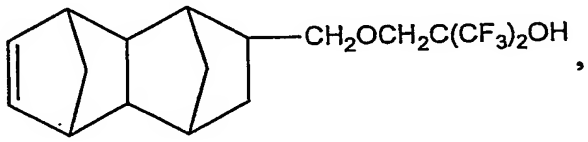
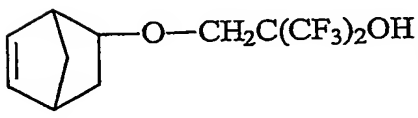
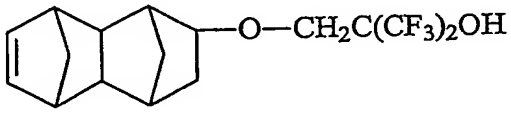


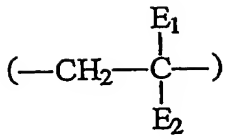
,

$CH_2=CHOCH_2CH_2OCH_2C(CF_3)_2OH$, $CH_2=CHO(CH_2)_4OCH_2C(CF_3)_2OH$,



and


9. The copolymer of Claim 5, further comprising at least one acid-containing or protected acid-containing structural unit:



wherein E_1 is H or C_1-C_{12} alkyl; E_2 is CO_2E_3, SO_3E, or other acidic group; and E and E_3 are H or unsubstituted or heteroatom-substituted C_1-C_{12} alkyl.

10. The copolymer of Claim 9, wherein the heteroatom is selected from the group consisting of oxygen, nitrogen, sulfur, halogen and phosphorus.

11. The copolymer of Claim 10, wherein the heteroatom is oxygen, and the substituent further contains a hydroxyl group.

12. The copolymer of Claim 9, wherein the acid-containing or protected acid-containing structural unit comprises a carboxylic acid group.

13. The copolymer of Claim 9, wherein the acid-containing or protected acid-containing structural unit is derived from a monomer selected from the group consisting of tert-butyl acrylate; 2-methyl-2-adamantyl acrylate; 2-methyl-2-norbornyl acrylate; acrylic acid; methyl acrylate; ethyl acrylate; propyl acrylate; 2-hydroxyethyl acrylate; 2-methoxyethyl acrylate; 2-cyanoethyl acrylate; glycidyl acrylate and 2,2,2-trifluoroethyl acrylate.

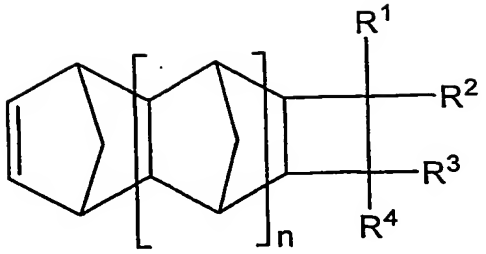
14. The copolymer of Claim 1, further comprising at least one group derived from a polar monomer.

15. A photoresist composition comprising:

(a) a fluorine-containing copolymer comprising:

(i) at least one repeat unit derived from an ethylenically unsaturated compound having at least one fluorine atom covalently attached to an ethylenically unsaturated carbon atom; and

(ii) at least one repeat unit derived from an ethylenically unsaturated cyclic compound of structure:



(I)

wherein n is 0, 1, or 2; and

R^1 to R^4 are independently H; $C_1 - C_{10}$ alkyl or alkoxy, optionally substituted by halogen or ether oxygens; or $C_6 - C_{20}$ aryl; and

(b) a photoactive component.

16. The photoresist composition of Claim 15, wherein (i) is derived from a fluoro-olefin comprising 2 to 20 carbon atoms.

17. The photoresist composition of Claim 16, wherein the fluoro-olefin is selected from the group consisting of tetrafluoroethylene; hexafluoropropylene; chlorotrifluoroethylene; vinylidene fluoride; vinyl fluoride; perfluoro-(2,2-dimethyl-1,3-dioxole); perfluoro-(2-methylene-4-methyl-1,3-dioxolane); $CF_2=CFO(CF_2)_tCF=CF_2$, wherein t is 1 or 2; and $R_f"OCF=CF_2$ wherein $R_f"$ is a saturated fluoroalkyl group of from 1 to 10 carbon atoms.

18. The photoresist composition of Claim 17, wherein the fluoro-olefin is tetrafluoroethylene.

19. The photoresist composition of Claim 15, wherein the fluorine-containing copolymer further comprises a fluoroalcohol group or a protected fluoroalcohol group.

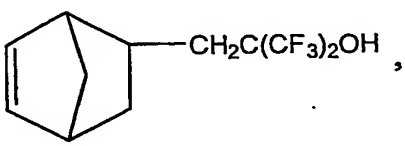
20. The photoresist composition of Claim 19, wherein the fluoroalcohol or protected fluoroalcohol group is derived from at least one ethylenically unsaturated compound containing a fluoroalcohol group having the structure:

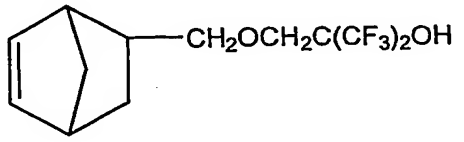
$$C(R_f)(R_f')OH$$

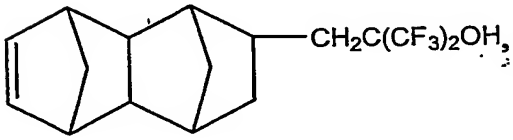
wherein R_f and R_f' are the same or different fluoroalkyl groups of from 1 to 10 carbon atoms, or taken together are $(CF_2)_n$ wherein n is 2 to 10.

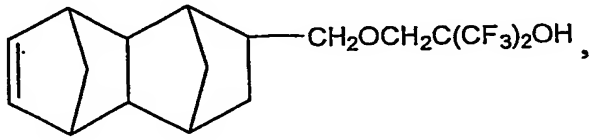
21. The photoresist composition of Claim 20, wherein R_f and R_f' are perfluoroalkyl groups.

22. The photoresist composition of Claim 20, wherein the fluoroalcohol group or the protected fluoroalcohol group is derived from a monomer selected from the group consisting of:

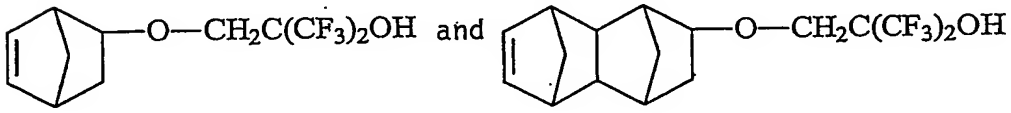




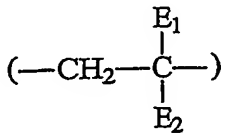




$CH_2=CHOCH_2CH_2OCH_2C(CF_3)_2OH$, $CH_2=CHO(CH_2)_4OCH_2C(CF_3)_2OH$,



23. The photoresist composition of Claim 15, wherein the fluorine-containing copolymer further comprises at least one acid-containing or protected acid-containing structural unit:



wherein E_1 is H or C_1-C_{12} alkyl; E_2 is CO_2E_3, SO_3E, or other acidic group; and E and E_3 are H or unsubstituted or heteroatom substituted C_1-C_{12} alkyl.

24. The photoresist composition of Claim 23, wherein the heteroatom is selected from the group of oxygen, nitrogen, sulfur, halogen and phosphorus.

25. The photoresist composition of Claim 24, wherein the heteroatom is oxygen, and the substituent further contains a hydroxyl group.

26. The photoresist composition of Claim 23, wherein the acid-containing or protected acid-containing structural unit comprises a carboxylic acid group.

27. The photoresist composition of Claim 26, wherein the acid-containing or protected acid-containing structural unit is derived from a monomer selected from the group consisting of tert-butyl acrylate; 2-methyl-2-adamantyl acrylate; 2-methyl-2-norbornyl acrylate; acrylic acid; methyl acrylate; ethyl acrylate; propyl acrylate; 2-hydroxyethyl acrylate; 2-methoxyethyl acrylate; 2-cyanoethyl acrylate; glycidyl acrylate and 2,2,2-trifluoroethyl acrylate.

28. The photoresist composition of Claim 15, wherein the fluorine-containing copolymer further comprises at least one group derived from a polar monomer.

29. The photoresist composition of Claim 15, wherein the photoactive component is a photoacid generator.

30. The photoresist composition of Claim 15, further comprising a dissolution inhibitor.

31. The photoresist composition of Claim 15, further comprising a solvent.

32. The photoresist composition of Claim 31, wherein the solvent is selected from the group of ether esters; ketones; esters; glycol ethers; unsubstituted or substituted hydrocarbons; aromatic hydrocarbons; fluorinated solvents and supercritical CO_2.

33. The photoresist composition of Claim 15, further comprising an additive selected from the group consisting of bases, surfactants, resolution enhancers, adhesion promoters, residue reducers, coating aids, plasticizers, and T_g (glass transition temperature) modifiers.

34. A coated substrate comprising:

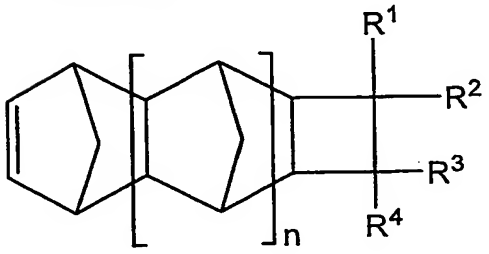
(a) a substrate; and

(b) a photoresist composition comprising a fluorine-containing copolymer comprising:

(i) a fluorine-containing copolymer comprising:

(a') at least one repeat unit derived from an ethylenically unsaturated compound having at least one fluorine atom covalently attached to an ethylenically unsaturated carbon atom; and

(b') at least one repeat unit derived from an ethylenically unsaturated cyclic compound of structure:



(I)

wherein n is 0, 1, or 2; and

R^1 to R^4 are independently H; $C_1 - C_{10}$ alkyl or alkoxy, optionally substituted by halogen or ether oxygens; or $C_6 - C_{20}$ aryl; and

(ii) a photoactive component.

35. The coated substrate of Claim 34, wherein the substrate is a microelectronic wafer.

36. The coated substrate of Claim 35, wherein the microelectronic wafer comprises a material selected from the group consisting of silicon, silicon oxide, silicon oxynitride, and silicon nitride.